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### The visual side of digital humanities

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what are their unique research benefits. With regards to that latter aspect and from the perspective of humanities research, especially novel qualities and opportunities for pattern recognition, an easy scalability and editing of information are mentioned (Moretti, 2007; Bodenhamer *et al.*, 2010b; Ch'ng *et al.*, 2013; Münster, 2016c).

The data foci of digital humanities are texts, images and objects. While the use of digital methods in the text-oriented disciplines is currently widely established and standardized (Bundesministerium Für Bildung Und Forschung, 2014, p. 10), a scope of digital methods related to images and other visual objects based on vision rather than close reading remains—despite various attempts (Bentkowska-Kafel *et al.*, 2006; Arnold and Geser, 2008; Frischer and Dakouri-Hild, 2008; Bodenhamer *et al.*, 2010; Ch'ng *et al.*, 2013)—essentially uncharted. Possible reasons may be seen in the ‘diverse nature of the methods used’ in disciplines focussing on these types of artifacts like art and architectural history, cultural heritage studies or museology (Long and Schonfeld, 2014, p. 48), but also in the heterogeneous level of establishment of digital research methods in those disciplines (Hicks, 2006). A common bond in visually oriented and digitally supported research in art and architectural history studies,<sup>1</sup> museology,<sup>2</sup> and archaeology,<sup>3</sup> as well as Cultural Heritage<sup>4</sup> may be their grounding in visual literacy. The concept of visual literacy “refers to a group of largely acquired abilities, i.e., the abilities to understand (read), and use (write) images [and spatial objects], as well as to think and learn in terms of images [and spatial objects]” (Avgerinou, 2001, p. 26). Within their meta-analysis, Avgerinou and Pettersson affirmed ‘art, philosophy, linguistics, psychology’ as parent disciplines for visual literacy as well as ‘visual thinking, visual learning & teaching, visual perception, and communication’ as the main constructs that underly it (Avgerinou and Pettersson, 2011, p. 4). Only a few publications link visual literacy and digital humanities. Jessop refers to the widely established London Charter (Beacham *et al.*, 2006) as a ‘possible framework for the development of appropriate methods and standards’ for the creation of visual content in the humanities (Jessop, 2008). Since the concept of

visual literacy originates in education, there are some publications about didactical and motivational aspects concerning visual literacy and (digital) humanities. As one example, Barber investigated digital Storytelling techniques for teaching history (Barber, 2016).

Visual literacy skills are not naturally given but must be learned (Avgerinou and Pettersson, 2011). Additionally, visual reasoning strategies highly relate to professional backgrounds (Goodwin, 1994). Since we would expect commonalities beyond the artefact between the disciplines dealing with vision in the digital humanities, we introduce 'visual digital humanities' as a novel 'umbrella' term to cover research approaches in the digital humanities dependent on both consuming and producing pictorial and spatial, rather than textual, information to answer their humanities research questions.

## 1.2 A definition of visual digital humanities

Visual digital humanities encompass the computational supported research on complex visual information to treat research questions and interests from the humanities.<sup>5</sup> According to Heusinger, computers support the work in art history, and, in a wider scope, in all visually oriented humanities disciplines, concerning aspects of:

- Data collection, e.g. through digitization;
- Data retrieval from database records with the transfer of knowledge;
- Examining visual humanities questions, e.g. a composition of complex figurative paintings;
- Reconstructing, simulating, and producing objects; and
- Administering and organizing people and objects.<sup>6</sup>

In our definition a range includes the analysis of complex visual information, their collection and semantic enrichment, as well as the creation of imagery in context of

- image analysis (e.g. the pattern analysis of large-scale image collections)
- perception based techniques (e.g. the visuospatial analysis of architectural objects)

- spatial modelling (e.g. 3D reconstruction of historical architecture)
- visualization (e.g. sketching for visuospatial reasoning).<sup>7</sup>

Therefore, a common bond can be found in the facts that objects are cultural heritage artifacts and images, and that scholars in visual digital humanities are using technologies to ‘understand (read), and use (write) images [and spatial objects], as well as to think and learn in terms of images [and spatial objects]’ (Horton, 1983) in humanities work.

We have introduced visual digital humanities from a theoretical perspective: our interest is now to investigate it empirically in order to specify its characteristics. Against this background, our research is intended to answer the following questions:

- How do researchers enter the visual digital humanities?
- Which are research topics and methods in the visual digital humanities?
- What are standards and challenges in visual digital humanities?
- Is there a specific scholarly culture in the visual digital humanities?

The outcome should be a state of the art sketch as well as implications for further organizational development, software design, and educational practice. While our approach is primarily based on qualitative empirical research methods, the intended outcome is to build hypothesis on the scope of the field of visual digital humanities, or those using and generating digital pictorial rather than textual information in the humanities.

## 2 Discussion

How do you investigate the characteristics of a scholarly area? Several approaches focusing on historical, philosophical, and sociological aspects (Becher, 1989; Krishnan, 2009), and various methods for the investigation of researchers and academic fields by empirical methods are provided by Science and Technology Studies (STS). A prominent

method characterizes fields of research by specific epistemic cultures in terms of different ‘architectures of empirical approaches, specific constructions of the referent, particular ontologies of instruments, and different social machines’ (Knorr-Cetina, 1999, p. 3), different techniques to gain insights, different vocabularies, different publication bodies, and habits (Cetina and Reichmann, 2015). According to this approach, scholarly fields are characterized to ‘(a) have a particular object of research [...], (b) have a body of accumulated specialist knowledge [...], (c) have theories and concepts [...], (d) use specific terminologies [...], (e) have developed specific research methods [...], and (f) must have some institutional manifestation in the form of subjects taught at universities or colleges [...].’ (Krishnan, 2009). Shared narratives are also important facilitators of a disciplinary culture, which has been investigated in Digital Humanities (c.f. Nyhan and Flinn, 2016). On a more operational level, the community of practice approach originally introduced by Lave and Wenger (1991) defines that these communities are marked by mutual engagement, a joint enterprise as well as a shared repertoire of knowledge and culture (Wenger, 1998). Against this background, three areas are of interest for our investigation:

- Scholars working in visual digital humanities
- Fields of research, topics and methods used by these scholars
- Institutionalization & disciplinary culture of these scholars.

## 2.1 Scholars in visual digital humanities

Research regarding scholarly behaviour often relies on analysing the publication record. With regards to a scholarly area of visual digital humanities and its adjacent fields like digital heritage, Hicks (2006) stated that publication habits as well as research habits widely spread between single disciplines in the (digital) humanities. Similarly, Leydesdorff *et al.* (2011) examined the disciplinary canon in humanities and digital humanities by employing bibliometric methods. With regards to a scholarly community within the digital humanities, Terras (2006b) reported that until 2006 especially US-, Canadian-, and UK-based researchers contributed

to academic discourse. Similarly, Grandjean performed a social network analysis of Twitter to map the digital humanities community (Grandjean, 2016). Specifically for digital heritage, Scollar (1997) investigated the Conference on Computer Application in Archaeologies (CAA) from 1973 until 1996, and (Münster and Ioannides, 2015) reviewed the Proceedings of CAA, DH, CIPA, VAST, 3DArch, and EUROMED between 1990 and 2015. As a result of both studies, researchers in the fields of digital heritage are primarily located in Mediterranean countries and have backgrounds in various disciplines—along with information technologies and humanities, these are primarily architecture, geo- and natural sciences. Secondly, information habits of visual digital humanities scholars are the focus of various studies. Since older investigations found large differences in information behaviour between scholars in different disciplines (Tenopir and King, 2008), nowadays many scholars in art history as well as in architecture intensively rely on digital information as well as perform visual search strategies (Beaudoin and Brady, 2011; Münster *et al.*, 2018). While Liu (2009) described general requirements for scholars in the field of humanities, Sprüker (2011) defined a set of competencies required to cope specifically with digital 3D reconstruction and visualization.

With regards to empirical investigations on computational literacy of visual humanities scholars, previous research draws an uneven terrain: for art creating scholars, Mason states that they are more 'library-literate than previous research on artists might have suggested' (Mason and Robinson, 2011), while Elam (2007, p. 6) notes that art historians lack digital technological competency in terms of 'rather limited awareness of electronic resources and haven't fully developed the skills to utilize them to their fullest potential'.

## 2.2 Fields of research and topics

What are fields of research in the digital humanities? Beside the already mentioned investigation done by Terras (2006b) on publications prior to 2006, Scott performed a similar analysis for the DH 2017 conference submissions (Weingart, 2016) and Tang *et al.* (2017) for journal articles in that field as

well as Given and Willson (2018) in particular for textual oriented digital humanities. A community identified by Terras' analysis exclusively dealt with textual and—few—image sources. In contrast, digital heritage related aspects as visualization, geospatial analysis or VR/AR were present in Scott's 2017's TOP-50 keyword list. Similarly, Tang *et al.* found out topics as 3D or Visualization less frequent occurring as keywords of academic journals in the field of Digital Humanities than textmining or TEI.<sup>8</sup> If visual content is only occasionally mentioned by a digital humanities community as defined by ADHO,<sup>9</sup> where does a discourse on visual digital heritage takes place instead? It can be stated that these topics have a long history. A very early bibliography specifically on images was compiled by Nowiskie (2002) in 2001. Much research on these topics is carried out by cultural heritage studies as well as by applying disciplines like archaeologies, museology or art and architectural history. With regards to that latter community, Drucker (2013) sketches a historical evolution as well as a current state of application of digital methods in art history. Complementary to this, Kohle (2013) defined fields of supplement by digital tools and practices in art history. The scope of topics of relevance for digital museology is currently being examined by the EU funded ViMM network (2017), which started in 2016. Similarly, many texts describe a comprehensive state of the art as well as methodologies for digital archaeology (e.g. Evans and Daly, 2006; Kansa *et al.*, 2011; Frischer and Dakouri-Hild, 2008). Furthermore, there are many standards and guidelines as well as rules defined and discussed for dealing with historical content (Sürül *et al.*, 2003; Beacham *et al.*, 2006; Pfarr, 2009; Bendicho, 2011; Kiouss *et al.*, 2011). Despite the broad variety of approaches and topics, digital cultural heritage evolved to a specific academic field with conferences, journals, and various frequently contributing researchers and institutions (Münster, 2017b). Particularly for monuments and art research the scholarly community is driven by researchers from European countries and especially Italy with a background in humanities. Most prominent research areas are data acquisition and management, visualization, or analysis. Recent topics are for instance



unmanned airborne vehicle (UAV)-based 3D surveying technologies, augmented and virtual reality visualization, metadata and paradata standards for documentation, and virtual museums. Moreover, conference series are most relevant for a scientific discourse, and especially EU projects set pace as most important research endeavours.

Finally, a definition of topics took place by curriculum setting initiatives. From the latter point of view, Sahle *et al.* (2013) defined a core curriculum which is intended to serve as a blueprint for a design of digital humanities courses in German academia—similarly, Svensson (2009) defined areas of interest for an international landscape in digital humanities. With regards to visual digital humanities, there is still no wide consensus on a specific education paradigm, and larger studies on the education of digital methods in visual digital humanities are still missing (Sprünker, 2013, p. 405). A set of topics of relevance for digital heritage in particular was defined by the ITN training network and comprised especially surveying database and visualization technologies (Ioannides, 2014).

### 2.3 Institutionalization and disciplinary culture

While the system that is still most established to classify epistemic spheres is ‘disciplines’,<sup>10</sup> an important characteristic of most current research work is their cross-disciplinarity (Krishnan, 2009). Against this background, various new scientific fields arose, which are constructed around certain methods or approaches and often connect to multiple disciplines.<sup>11</sup>

Especially from the perspective of digital humanities there is much research on aspects of institutionalization and culture (cf. Hayles, 2009; Svensson, 2010; Nyhan and Flinn, 2016). A joint object of research in (visual) digital humanities is defined by Alvarado in reference to Panofsky as '[...] the records left by man' (Alvarado, 2011)—products and traces of human intellectual labour. On aspects of institutionalization, a discourse is primarily driven by curriculum setting initiatives. Since there are various publications providing an overview on course programs (Terras, 2006a; Duwe

and Meffert, 2008), institutions (Stergios, 2016), and organizational habits (Liu, 2009; Svensson, 2009; Svensson, 2010) in digital humanities, no comparable overview is yet known for visual digital humanities in particular. An important feature is the interdisciplinary nature of a collaboration in digital humanities. Especially in the German-speaking world, there is a distinction between e(nhanced) humanities, collaboration between humanities and computer science (BMBF, 2014), as well as digital humanities as a ‘hybrid discipline’ (Cologne Center for eHumanities, 2011), which includes approaches and methods of both disciplines. Since the quality of cooperation is still discussed in literature, it is undoubted that cross-disciplinary cooperation is a central characteristic of (visual) digital humanities. In contrast to philosophical approaches, there is little empirical research on practices and users of digital reconstruction (cf. Huvila, 2014). Huvila investigated user roles and practices in archaeology (Huvila, 2006, 2010) as well as certain practices within the ongoing ARKDIS project (ARKDIS). Another empirical perspective is the research on usability and requirements for software design for humanities researchers which was investigated within the VERA project (Fisher *et al.*, 2009; Warwick, 2012) as well as by Given and Willson (Given and Willson, 2015) for scholars in the UK and Canada.

What are conclusions for our research? Since a joint object of research in (visual) digital humanities is cultural heritage in terms of images and artefacts, there are various sub-communities related to original disciplines, specific technologies, or dedication to education, history studies or preservation of artefacts. Despite various differences, joint attributes are project orientation, cross-disciplinary cooperation and dependency on technologies and data. Since there are various studies on disciplinary cultures in the visual oriented branches of digital humanities, research often focuses on specific communities such as digital art history or archaeology. In addition to the already named objectives for our empirical investigation, we will highlight the communalities and differences beyond links to both visual methods and digital humanities.



the relation between visual digital humanities and other disciplines. According to the *theoretical sampling* principles, such multi-cohort design allows to investigate potential factors and micro-hypothesis in more detail than by employing a single cohort design (cf. Strauss and Corbin, 1996). In total, 15 interviews were carried out—7 in the first, 4 in the second and another 4 in the third cohort.

### 3.2 Data collection

For an investigation of complex and non-trivial processes, mainly guideline-based expert interviews are suitable (Mieg and Näf, 2005; Gläser and Laudel, 2009). These forms provide—compared to e.g. questionnaires—a less structured qualitative toolset, combining a set of anchor questions with the freedom to follow up points as necessary (Thomas, 2009, p. 164; Zina, 2010, p. 195). Each interview lasted between 10 and 60 minutes. All interviews were recorded and semi-automatically transcribed by using the Pop Up Archive service in a non-public way (2016). All interview data were anonymized for further analysis.

### 3.3 Data analysis

Data analysis was undertaken using approaches of qualitative content analysis (Mayring, 2008) to (1) inductively gain an initial category scheme and (2) deduce it to further materials. This resulted in both an inductively generated categorization scheme as well as a set of related variables and occurrences.

### 3.4 Limitations

Since this is an interpretative and explorative study (cf. Bhattacharjee, 2012) a general limitation is that it neither test hypothesis nor deliver quantifiable results in terms of exact measures. Moreover, potential weaknesses and limitations are caused by a potentially flawed sample—e.g. since the focus is on researchers based in London—and the qualitative and therefore maybe biased evaluation paradigm.

## 4 Findings

#### 4.1 Visual digital humanities scholars

What are the disciplinary backgrounds of scholars in visual humanities? All queried persons started their

academic education in an adjacent discipline but not in digital humanities itself.<sup>14</sup> With regards to their formal graduation, interviewed scholars primarily have humanities or technical backgrounds—in two cases both (PostDoc Researcher in Digital Humanities, 2016b; PhD student in Geosciences, 2016). Related humanities disciplines are archaeology, architectural history, medieval history, classics, information, and literature studies (PostDoc Researcher in Spatial Humanities, 2016; PhD student in geosciences, 2016, lines 5–7; Head of Information Technologies in Museum, 2016, line 17, Digital Humanities Coordinator; 2016, line 51). As background in engineering, primarily computing was named (Professor in Computing, 2016, line 25; PostDoc in information technologies, 2016, Research administrator in Digital Humanities, 2016, line 15), further geosciences (PhD student in geosciences, 2016, line 23) as well as architecture and cultural heritage conservation (Research Associate in Remote sensing, 2016). Another researcher holds degrees in both archaeology and cultural heritage management (PostDoc in Digital Humanities, 2016). A resultant hypothesis would be that visual digital humanities researchers have a wide scope of academic backgrounds primarily in technical disciplines or the humanities, but often have a history of interdisciplinarity.

Reasons given for entering the field of visual digital humanities varied. The majority of interviewees mentioned that their motivation to enter the field of digital humanities was widely driven by personal research interests requiring complementary skills. Where these interests were coming from:

- (a) ... *another application area*: With regards to a relation between academic origin and interest, in most cases research interests are grounded in researcher's original discipline, e.g. a computing engineer 'got into the habit of applying my computer graphics toolbox' to cultural heritage objects (Professor in Computing, 2016, lines 36–37). Vice versa another researcher argued to 'bringing the humanities skills to bear on the question of digital technology' (PostDoc Researcher in Spatial Humanities, 2016, line 48).



- (b) *Curiosity*: In contrast, a cultural heritage management scholar did her PhD in digital humanities while wanting to know about a certain topic from a meta-perspective, in particular to 'better understand and find the patterns and themes in the behaviour of scholars' (PostDoc Researcher in Digital Humanities, 2016a, line 11).
- (c) *Professional needs*: Another motivation was driven by professional needs, in case of a researcher who works in an urban planning interest group '[the use of GIS] was the only way that I saw that multiple audiences could actually extract information' (PhD student in geosciences, 2016, line 15).

In contrast, four researchers who entered the field of digital humanities as computing engineers figured out that their entrance in digital humanities took place via employment in a project (Research administrator in Digital Humanities, 2016, line 15; PostDoc Researcher in Spatial Humanities, 2016, line 18; PostDoc Researcher in Digital Humanities, 2016b, line 31; Research Associate in Remote sensing, 2016, line 19). That leads to the hypothesis that especially for humanities researchers, the motivation to enter the field of visual digital humanities is widely driven by research interests, and using appropriate methods to answer research questions. This corresponds with studies about students' epistemological belief. According to Paulsens and Wells investigation from 1998 students from humanities are more deeply reflecting about knowledge (. . . and research practices) as well as being willing to learning about non-familiar topics than in applied disciplines as engineering (Paulsen and Wells, 1998; Paulsen and Feldman, 2005).

Similarly, How do individuals learn visual digital humanities methods?

As a closely linked question, how do scholars in the field of visual digital humanities acquire knowledge in complementary areas?

- (a) *Studying courses in the complementary discipline:* In one single case the researcher ‘did the masters [course] of the advanced visualization and analysis [...] which is the hardest thing I’ve ever done. Lot of maths. I don’t come

from a math background [...]. I just sit and look at equations and think this is so exciting [...]' (PhD student in geosciences, 2016, line 23–25).

- (b) *Self-driven learning by learning using materials:* Primarily humanities researchers who went into coding mentioned that a use of learning materials was their primary resource. This comprises for example online tutorials,<sup>15</sup> web resources and books.<sup>16</sup>
- (c) *Learning by experience:* Remarkably, it was mainly engineers who said that they did not specifically study humanities topics, but got familiar with this content by cooperating with humanities scholars. Nevertheless, they would estimate their level of expertise in humanities as merely basic.<sup>17</sup>

It is interesting that primarily scholars with an original background in the humanities claim to acquire digital skills by doing courses or tutorials. Also from a coordination perspective, current attempts focus on a training of humanities scholars to ‘improve the digital skills’ (Digital Humanities Coordinator, 2016, line 7). A general enhancement of digital competencies in humanities is underlined by another estimation of a researcher on information practices in art history: ‘[Younger] art historians being more reluctant to employ new technologies’ (PostDoc Researcher in Digital Humanities, 2016a, line 15). An adjacent question would be whether, vice versa, ‘technologists would have to learn humanities skills? With regards to a formal teaching program in digital humanities, [...] very, very few [students] [...] have a technical background’ (Senior Lecturer in Digital Humanities, 2016, line 113). Similarly, all interviewees originating from a technical discipline stated that their experience came from practising in digital humanities,<sup>18</sup> even if they estimate their level of expertise in humanities issues as limited.<sup>19</sup>

Important prerequisites for digital visual humanities are not to have a specific disciplinary background (Senior Lecturer in Digital Humanities, 2016, line 111–113), but to have good maths and coding skills—which was named by three of the interviewees (Professor in Computing, 2016, line 149; PhD student in geosciences, 2016, line 23;

Head of Information Technologies in Museum, 2016, line 73). A critical comment was made about the depth of acquired skills: ‘We have lots of projects where we have people that say databases or thinking about text mining but not knowing how to do it’ (Head of Information Technologies in Museum, 2016, line 17–19). Resultant hypotheses are that important skills for employing visual digital humanities methods are maths and coding. Primarily humanists entering the field of visual digital humanities have to acquire additional skills in maths and coding areas.

Since currently many university level programs in digital humanities are offered, esp. at masters level (cf. Duwe and Meffert, 2008; Sahle, 2013), it was interesting to note that none of the interviewees claimed to have graduated in these programs. An explanation offered by one of the interviewees is that specific digital (visual) humanities study programs have only been offered within the last 10 years (Professor in Information Studies, 2016, line 17), and graduates will rarely be found as active members of a scholarly community yet, due to ‘the very long pipeline’ from studying to academic establishment.<sup>20</sup> With regards to a comparable situation in computer graphics, another interviewee figured out that ‘people of my generation [...] had their supervisors who themselves were electrical engineers, mechanical engineers, architects, mathematicians, physicists’ and brought their scholars primarily in these communities (Professor in Computing, 2016, line 77–79).

## 4.2 Fields of research, topics, and methods

#### 4.2.1 *Fields of research*

Another interest of this article was to identify research topics in the field of visual digital humanities. With regards to surveys undertaken during the ARKDIS conference as a conference in particular on information in the archaeology (cf. Table 3), less surprisingly a majority of researchers work on topics of data management and acquisition—including aspects like data retrieval, data processing, data indexing, and data storage. Other areas of importance are data visualization as well as communication—especially with regards to crowd

**Table 3** ‘What are your fields of research related to archaeological information/visual humanities?’ (Questionnaire based survey carried out at ARKDIS conference, 23 contributors, 76 answers)

Category	Count	Examples
Data management	11	e.g. GIS, databases, metadata
Data acquisition	8	Photogrammetry, laser scanning, computer vision
Communication	6	Museum exhibition, crowdsourcing
Visualization	5	
Analysis	4	e.g. visual or spatial analysis
Methods	4	
Modelling	2	e.g. 3D modelling
User Practices	2	
Documentation	1	
Education	1	
Others	9	

involvement and participation via crowdsourcing. A use of digital humanities methods for data analysis and a—not further specified—research on methods were mentioned in four cases.

With regards to the findings from the interviews, some more detailed information on research methodologies was provided. Research approaches can be distinguished as:

- (a) User behaviour studies: The investigation of the information behaviour of researchers as well as the development of supporting technologies were named by four interviewees. A thematic scope comprises the investigation of image related information management by humanities scholars (PostDoc Researcher in Digital Humanities, 2016a) as well as by professional image users as for example journalists (Senior Lecturer in information technologies, 2016) and user interaction with interfaces (Professor in Computing, 2016; Research administrator in Digital Humanities, 2016; Senior Lecturer in information technologies, 2016).
- (b) Data analysis as pattern extraction from data and their investigation was in focus of four researchers, too. One research project dealt with an extraction of metadata from archaeological excavation reports by using language

processing tools (PostDoc Researcher in Digital Humanities, 2016b). A similar approach done by another researcher was for the abstraction of dance movements from video material via structure from motion (SFM) (PostDoc in information technologies, 2016). A third researcher investigated change patterns of urban housing during time from GIS data (PhD student in geosciences, 2016).

- (c) Data acquisition and spatial modelling in terms of digitization of analogue sources was mentioned by two researchers in context of 3D content creation primarily by photogrammetric and laser-based acquisition of physical cultural heritage sites and objects (Professor in Computing, 2016, line 27; Research Associate in Remote sensing, 2016, line 27).
- (d) Crowd participation is a topic in three research tasks. An example is the development of platforms for crowd participation.
- (e) Visualization: Two researchers mentioned 3D printing as well as computer graphic approaches, whereby there is an interest for both the development of intuitive human computer interaction metaphors and algorithms.
- (f) Interfaces: Two researchers deal with topics of user communication. Two researchers build digital applications and interfaces to access visual data from image collections (Senior Lecturer in information technologies, 2016) and 3D models derived from objects in museum collections (Head of Information Technologies in Museum, 2016). Related research interests are for user experience and interface design.

This contrasts to the findings of Eichmann *et al.* (2016) concerning keywords of the ADHO Digital Humanities conference series, whereas analysis—namely text and data mining—are ranked first, followed by ‘Literature studies’ and ‘Archives, Repositories, Sustainability And Preservation’. Therefore, it may be questioned, whether particularly analysis is a less relevant or more diverse topic in the visual-oriented digital humanities than in the textual-oriented field.

### 4.2.2 Hot topics

In addition to the question of ‘personal’ topics, another interest was to examine current ‘hot’ topics in the field of visual digital humanities. Corresponding to previous investigations on the particular field of digital 3D modelling (Münster, 2017a), a scientific discourse is widely driven by technological trends.

#### 4.2.2.1 Big data

Consequently, one of the current hot topics—mentioned by three interviewees—also in visual digital humanities is Big data in terms of ‘large volume[s]’ as terabytes and beyond ‘of objects to process’ (Research Associate in Remote sensing, 2016, line 47). Since big data-based research adds opportunities such as the processing of large cohorts of information without reduction, it also adds ‘some massive challenges’ (Professor in Computing, 2016, line 97) in terms of efficient algorithms, and high ‘[...] computer power, bandwidth [and] storage’ (Professor in Computing, 2016, line 99) requirements have to be mentioned here.

#### 4.2.2.2 Virtual and augmented reality

As mentioned by two researchers, virtual and augmented reality visualizations are popular in visual digital humanities, too, and are primarily used to present 3D scaled cultural heritage content (Professor in Computing, 2016, line 159).

#### 4.2.2.3 Pattern recognition

The recognition of patterns especially not only by machine-learning approaches, but also with regards to appropriate interfaces to support human vision of large scale information, is another ‘hot topic’ and was named by two of the interviewees. Even if the potentials of machine learning for humanities research are undoubted, for instance to automatically classify manuscripts (Professor in Computing, 2016, lines 49–51), they ‘might not be an easy sell because [...] trying to replicate [researchers work by computers may be seen] [...] pretentious if not even heresy [by humanities scholars]’ (Professor in Computing, 2016, line 10).

#### 4.2.2.4 User engagement

Various approaches to user engagement were named as ongoing topics by four interviewees in

total. A list of mentioned topics also reflects current hot topics and comprises digital storytelling (Head of Information Technologies in Museum, 2016, lines 10–11), especially for museum education, as well as citizen science and crowdsourcing to classify, enrich, or assess large-scale amounts of digital content. Moreover, aspects of ‘openness’ and sharing of content are in focus—for instance, for 3D digitized artefacts (Research Associate in Remote sensing, 2016, line 47).

### 4.2.3 Research methods

Since research methods in digital humanities obviously incorporate both technical and humanities perspectives, our interest was to investigate which methods are applied by individual scholars. Generally, visual digital humanities are marked by a big ‘diversity of topics and methods [as well as] [...] different practices and [...] different approaches’ (PostDoc Researcher in Digital Humanities, 2016a, line 31). On a general level, three different sets of methods could be identified:

- The ‘humanities’ method set primarily focuses on the investigation of research questions by interpretation (cf. Digital Humanities Coordinator, 2016, lines 33–35). In digital humanities project, this mainly comprises the skills to frame relevant research questions and to ‘evaluate a variety of different sources’ (Senior Lecturer in Digital Humanities, 2016, line 49).
- The ‘engineering’ method set comprises various approaches to ‘synthesize new things [...] and then [to] analyse them’ (Professor in Computing, 2016, line 65). Research ‘method’ is primarily to conceptualize, build and evaluate prototypes (Research Associate in Remote sensing, 2016, line 27).
- The social sciences method set: Numerous scholars employed methods deriving from empirical social sciences for their research. That comprises quantitative and qualitative approaches like interviews (PhD student in geosciences, 2016; PostDoc Researcher in Digital Humanities, 2016a) and surveys (Head of Information Technologies in Museum, 2016) as well as

observation e.g. of user behaviour (Senior Lecturer in information technologies, 2016; Research administrator in Digital Humanities, 2016).

How are these set of methods employed in digital humanities research projects? With regards to our interviews, we identified three prototypic modes to combine these method sets:

- (a) *Cross-disciplinary research teams:* In most digital humanities projects, different method sets are employed by different research team members—for instance, humanists, who determine a research interest, select sources and interpret results, while engineers develop and test a software application. Against that background, research methods are primarily adopted from the disciplines the scholars originally graduated in. Moreover, these researchers primarily participate in scientific communities in their original disciplines or involve perspectives from their original disciplines into cross-disciplinary publications.
- (b) *Digitally enhanced research:* As stated in the previous paragraph, it is mainly researchers from the humanities who acquire computing skills to foster their research interest in the humanities. Even if they partly achieve excellent practical skills,<sup>21</sup> their fields of research excellence are still related to their original scientific disciplines.
- (c) *Mixed-methods researchers:* A relatively small number of scholars—three in our sample—base their research on methods from various disciplinary spheres and received scientific merits in multiple disciplines. In our sample, these approaches are practised exclusively by people with degrees in two disciplinary spheres—e.g. humanities and engineering (Professor in Digital Humanities, 2016; PhD student in geosciences, 2016) or humanities and social sciences (PostDoc Researcher in Digital Humanities, 2016a).

This finding may contrast to the finding of Given and Willson for textual-oriented digital humanities, where tool development became an essential skill for researchers (Given and Willson, 2018).

### 4.3 Visual digital humanities and their culture

#### 4.3.1 A practice-grounded definition

With regards to definitions retrieved from the interviewees, digital humanities as the umbrella of visual digital humanities are characterized by the use of computational processes to investigate the culture of the past (Professor in Digital Humanities, 2016, line 125) from a humanities' point of view (Professor in Information Studies, 2016, line 41). It is characterized by 'interdisciplinary team[work] [...] but also moves towards openness and sharing' (Senior Lecturer in Digital Humanities, 2016, lines 89–91). Moreover, digital humanities are 'around the subject' (Head of Information Technologies in Museum, 2016, line 22) in terms of comprising a wide scope of methods and approaches as well as being practice oriented.

#### 4.3.1.1 A state of establishment

Digital humanities are still widely seen as ‘emerging’ as they ‘have to [...] establish [their own] research philosophy, [...] research methodology and [...] learn from [...] other disciplines’ (Professor in Information Studies, 2016, line 19). Against this background, interviewees distinguish between a state of maturity in terms of involved researchers and in terms of organizational development. With regards to that first aspect, one of the interviewees argued that the zenith of digital humanities is over now and ‘a certain point [...] when there’s enough teaching programs, [...] enough people involved in the society [...]’ (Professor in Digital Humanities, 2016, line 149) has been reached. From an organizational perspective, several researchers argued that it takes ‘a very long time, [sometimes] [...] two generations of scholar[s]’ (Professor in Information Studies, 2016, line 19) to establish a novel academic discipline. A prediction of the future role of digital humanities widely varies. While ‘some interviewees would see digital humanities as an academic discipline in future, others expect a massive impact on humanities, which changes [...] the nature of humanities’ (PostDoc Researcher in Spatial Humanities, 2016, lines 73–74). This discussion reflects findings in other

research, whereas the question for current state of establishment differs (Nyhan and Flinn, 2016)

#### 4.3.1.2 Small communities

Even if most interviewees agreed in being part of a digital humanities community they are often not active members there, but in smaller sub-communities on specific topics like urban history geomatics (PhD student in geosciences, 2016) or web archivism (Digital Humanities Coordinator, 2016). These sub-communities are characterized by '[...] not a lot people in it' (Head of Information Technologies in Museum, 2016, line 27). Since it is '[...] very hard to find people who are actually interested in [for instance] the big picture of a city [...]' (PhD student in geosciences, 2016, line 21), it sets the necessity for intensive cross-national exchange. A resultant hypothesis is that visual digital humanities subsume various smaller scientific communities.

#### 4.3.2 Cooperation cultures

#### 4.3.2.1 Cross-national cooperation cultures

Maybe for these reasons of specialist small communities, Digital Humanists estimate themselves as internationally well linked. With regards to academic excellence, visual digital humanities are led by researchers in the USA where that field has ‘really far more [importance] than it has in the UK’ (PostDoc Researcher in Spatial Humanities, 2016, lines 73–74). From the perspective of London universities, there are close ties especially not only to American institutions but also to various European countries in terms of joint projects and conferences. For instance, one museum researcher mentioned that some of their research was funded by a private US foundation (Head of Information Technologies in Museum, 2016). With regards to the internationality of staff and students, four of the interviewees in London were not originally British but emigrated from other European countries. In contrast, a large number of students in digital humanities courses are not English originally within that population, the biggest group of around ‘twenty [to] twenty five percent is Chinese’ (Senior Lecturer in Digital Humanities, 2016, line 199), which leads to



the hypothesis that scholars in visual digital humanities are internationally well linked.

#### 4.3.2.2 Private–public partnership

Another finding was that occasionally commercial partners got involved in research projects, too. While museum projects, in particular, get wide support by companies,<sup>22</sup> a private-public partnership in academic projects was described as difficult due to the expectations of the commercial partners as well as problems with institutional funders in case of mixed funding.<sup>23</sup>

#### 4.3.2.3 Cross-disciplinary cooperation cultures

Cooperation between different disciplines is one of the most evident attributes of visual digital humanities. Against this background, interviewees pointed out several aspects which complicate collaborations.

#### 4.3.2.4 Problem versus question-oriented research

Visual digital humanities ‘require[s] engineers and humanities scholars to directly engage with each other [...]’ ‘to produce [...] more meaningful outcomes [...]’. As ‘engineers we’re always looking for problems to solve’ (Professor in Computing, 2016, line 39) while a representative of the humanities is highly question-oriented, so ‘it’s a very different perspective [...]’ between these both approaches (PostDoc Researcher in Spatial Humanities, 2016, line 69).

#### 4.3.2.5 Single versus team-based research

While engineering disciplines and in particular computer sciences as relatively young areas tend to perform their work in interdisciplinary and team settings, traditional humanities research was performed by solitary researchers (cf. De Solla Price, 1963).

#### 4.3.2.6 Fuzzy versus static

‘I sometimes feel that brings us closer to the humanities than let’s say a purely sound scientific approach because in the humanities as well there is always room for synthesis. You’re always allowed to [...] put something out

there to come up with a hypothesis to and then see what happens. When we build systems we have to live with it' (Professor in Computing, 2016, lines 85–87).

#### 4.3.4.7 A clash of cultures

As a consequence, a cooperation quality highly depends on:

- *mutual respect*: ‘require engineers and humanities scholars to directly engage with each other you know develop an appreciation of each other’s approaches before something can come out of that’ (Professor in Computing, 2016, line 109). Opposite: ‘I’ll criticize engineering for coming on to a problem and thinking they can solve it. Humanities is easy (Research administrator in Digital Humanities, 2016, line 51).
- *understanding of mutual benefits*: ‘I might be able to help answer those questions but I don’t know what the fundamental questions are in a particular field. And that’s where the collaborative is necessary’ (Research administrator in Digital Humanities, 2016, line 41–43). ‘And as engineers we’re pretty good at finding [...] a good sweet spot in terms of system design [as problem solving]’ (Professor in Computing, 2016, line 45). As a consequence, a basic task is to highlight mutual benefits, since for instance humanities researchers ‘[...] very often [...] don’t know yet what they want this morning teasing out and trying to find some sort of a series of questions [...] [to identify how] [...] they going to use [...] [digital methods]’ (Research Associate in Remote sensing, 2016, line 30).
- *common ground of understanding*: ‘I find that usually how people speak to each other varies by disciplines and very often I need to translate [...] between disciplines’ (PhD student in geosciences, 2016, line 16).

These findings widely correspond to our previous investigations, e.g. in the field of Digital Heritage (cf. Münster, 2016b). In comparison to general problems named for interdisciplinary research, both Digital Humanities Digital Heritage seem well established. Both already have specific

publications bodies, so for instance the problem of a lack of appropriate publication venues, which often hinders interdisciplinary research (cf. Wessner and Kienle, 2007) may not apply here.

#### 4.4 Standards and challenges

#### 4.4.1 Standards

What are people defining as standards in the field of visual digital humanities? During a workshop held at the ARKDIS conference in 2016 people were asked to name ‘gold standards’ in terms of most relevant items (cf. Table 4). Even if the conference audience may represent a particular community on information studies in archaeology, some interesting findings could be retrieved.

While both publications and projects were named manually in the questionnaire as anchor examples, it was remarkable that various data repositories and services were named as ‘standards’, which underlines the high relevance of data as well as the availability of high-quality infrastructure suppliers. Moreover, ‘methods’—even if named as anchor example—were named only occasional. A resultant hypothesis is that standards in visual digital humanities are primarily defined by publication bodies, technologies, projects, and repositories. An explanation may be that Digital Heritage is—as mentioned by a head of digital museum technologies—‘around the subject’—incorporating a wide plurality of contributing institutions as well as methods and approaches.

**Table 4** ‘What are “gold standards” in your field of research?’ (Questionnaire-based survey carried out at ARKDIS conference, 21 contributors, 56 answers)

Item	Count	Examples
Publications	20	e. g. CAA, J. of Archaeological Method and Theory
Repositories	12	
Projects	8	
Institutions	5	
Standards	4	
not recognizable	4	
Methods	2	
Others	1	

#### 4.4.2 Current issues in digital humanities

#### 4.4.2.1 Data accessibility

A majority of interviewees estimate the access to data as the ‘biggest challenge’ of digital humanities (eg. PhD student in geosciences, 2016, lines 119–23). That includes for instance aspects of data availability which is limited by legal barriers or company ownership. Since ‘much data is being shared by services like Facebook’, it is ‘[potentially] going to be locked away and inaccessible’ for researchers (Digital Humanities Coordinator, 2016, line 73). Moreover, with regards to aspects of long term preservation and availability ‘we can’t rely on commercial companies to pay for this’ (Digital Humanities Coordinator, 2016, lines 73–76). Various governmental initiatives demand to make data created by public institutions available for everyone to equal conditions. That makes it impossible for museums to contribute to research projects without making their digital assets fully available for commercial exploitation (Head of Information Technologies in Museum, 2016, line 20).

Beside the vast data not available online for various reasons, much data is currently not properly accessible due to insufficient tagging, indexing or linking (cf. e.g. Rimmer *et al.*, 2008; Friedrichs *et al.*, 2018). As a consequence, ‘we don’t really know what’s in there, if [...] web page [links to] [...] broken images’ (Digital Humanities Coordinator, 2016, lines 25–27). Finally, this relates to the question how to archive and preserve complex digital data as for example ‘digital art’ (Digital Humanities Coordinator, 2016, Line 115).

#### 4.4.2.2 Legal issues of research software

Just as legal issues may hinder access to data, another challenging aspect is seen in the non-transparency and restrictions of commercial research software. This causes problems in making research outcomes fully transparent, and funding and institutional affiliation is required to be able to use research tools.<sup>24</sup>

#### 4.4.2.3 Increasing complexity of research

Another challenge is seen in the increasing complexity of research approaches in (visual) digital humanities. As stated by a professor in information

technologies, recommendations for software programming in humanities tend to be ‘much more complex than [in] other discipline[s]’ (Professor in Computing, 2016, line 45). While humanities disciplines like image history or linguistics traditionally focus on specific media types, there is a current trend to investigate research issues by taking various material into account—‘visual material as well as the text[s]’ (Digital Humanities Coordinator, 2016, line 27). As a consequence, occasionally novel cross-disciplinary academic units appear which are dedicated to a specific issue such ‘as the science of cities’ (PhD student in geosciences, 2016, line 179).

Finally, against the background of a currently primarily tool oriented academic discourse on visual digital humanities, it is seen as a big challenge there to develop ‘not just the tools but theoretical frameworks for all of them’ (Digital Humanities Coordinator, 2016, line 57).

## 5 Implications

### 5.1 Visual digital humanities researchers

What are lessons learned from this research? Scholars in visual digital humanities derive from many subject areas: in our investigation especially engineering, humanities, and social or informational studies. Only one of the interviewees originally graduated in digital humanities. With regards to the mentioned long duration of becoming established in academia and vice versa, the currently short history of native digital humanities courses and graduations—which only became available in the early 2000s—it would be a prospective task to monitor how this situation, and the academic trajectory of those in the digital humanities field, develops in future.

## 5.2 A wide scope of topics, approaches, and methods

While there is a wide scope of topics addressed, data access seems to be the most crucial point. Both data acquisition and management are the most prominent research areas. Topics are widely influenced by current trends in technology and society, which may

be caused by the opportunities to pitch for funding for projects by referring to up-to-date issues. Moreover, visual digital humanities topics are not merely a movement to ‘redefine traditional humanities scholarship through digital means’ (Adams and Gunn, 2013). Beside the ‘technology-enabled’ use of computational technologies to answer new types of research questions and the ‘technology-facilitated’ employment of computational technologies as medium ‘for new research practices without necessarily transforming researchers’ methods’ (Long and Schonfeld, 2014, p. 42), a third type of research approach became apparent: ‘humanities-enabled’ research as trading in humanities techniques to answer technology related questions like user-engagement, research ethics, or to perform a comprehensive explanation of technical results. Moreover, a disciplinary identity of visual digital humanities is primarily defined by publication bodies, repositories, and projects. In contrast, there are probably neither single institutions nor methods explicitly mentioned as standard—maybe due to the ‘diverse nature of the methods used in art history’ (Long and Schonfeld, 2014, p. 48).

### 5.3 Visual digital humanities and their culture

### 5.3.1 Visual digital humanities as cross-disciplinary work

A key aspect of visual digital humanities is cross-disciplinary cooperation. Even if many researchers argue that digital humanities are (... or should be ...) a ‘Two-Way Street’ (e.g. Flis *et al.*, 2016), it occurs in practice often as an adoption of digital skills by humanities scholars or as cross-operational projects. In contrast, a wider adoption of humanities skills by engineers rarely takes place. Are digital humanities projects for engineers just ‘another field of application’ (Münster, 2016b, p. 357)? Even if engineers would estimate their research as topic independent ‘problem solving’, original research challenges in digital humanities are caused by the high complexity of questions (Professor in Computing, 2016, line 45) and the fuzziness of humanities research. Some principles to foster that cooperation may be seen in mutual respect, the understanding of mutual benefits and the

development of a common ground of understanding—in terms of a shared terminology but also as a moderation of interests. Since experience is a most crucial factor in managing cross-disciplinarity, ‘established digital humanities research centers, and some academic libraries collaborating with such centers’ may fertilize that (Beland, 2016).

### 5.3.2 Digital humanities as Mode 2 research

Digital humanities could be seen as a mode 2 research with an emphasis on cross-disciplinary teamwork, the use of machines and a joint intellectual property (Professor in Computing, 2016).<sup>25</sup> Since a disciplinary culture on that type of research is widely common in engineering but less in humanities<sup>26</sup> that may explain why humanities scholars report the need to qualify to enter the field of digital humanities much more than engineers.

### 5.3.3 Are digital humanities still an emerging field of research?

With special regards to art history, Zorich stated various discipline related barriers (Zorich, 2012, p. 19): a conservative disciplinary culture, ‘outmoded reward and evaluation systems’ which do not reward digital work and the ‘belief that print is the only valid form of publication’. According to Long and Schonfeld, ‘at present, though, new digital methods are still seen as risky and experimental. Even where there are excellent support services for art historians who want to apply digital methods, only a minority of art historians [...] are interested in using these methods’ (Long and Schonfeld, 2014, p. 43). While for digital humanities in general further progress is currently not undoubted, visual digital humanities would still have the potential to evolve.

## 6 Conclusion

What is next in visual digital humanities? As there is an established scholarly community of researchers who work on a broad scope of topics, there are numerous established conference series and journals dealing with topics of visual digital humanities, in particular with focus on digital cultural heritage (Münster, 2017b). Furthermore, there are specific

funding programs around topics of digital heritage and digital humanities, some first obstacles for further institutionalization have already been mastered. During our investigation we examined numerous hypotheses to be tested in further studies:

- Visual digital humanities scholars' academic backgrounds are primarily in technical disciplines or humanities.
- Especially for humanities researchers, the motivation to enter the field of digital humanities is widely driven by interests.
- Important skills for visual digital humanities are maths and coding.
- Primarily, humanists entering the field of visual digital humanities have to acquire additional skills.
- The current generation of visual digital humanities scholars have seldom originally graduated in digital humanities—yet.
- Scholars practice research in the fields they have originally graduated in.
- Visual digital humanities subsume various smaller scientific communities.
- Scholars in visual digital humanities are internationally well linked.
- Standards in visual digital humanities are primarily defined by publication bodies, technologies, projects, and repositories.

With regards to recent organizational development, e.g. of eLearning (cf. Euler and Seufert, 2005), future important steps on the way to institutionalization of (visual) digital humanities as an academic field or discipline will be the development of specific methods, institutions, and curricula. While the text-oriented branches of digital humanities have stepped into that stage a decade ago, it is currently ongoing for visually oriented fields with some first professorships on digital heritage methods or digital art history. As the work of visual digital humanities is primarily set around tools (Ballon and Westermann, 2006) and their practical application, the question for a sufficient level of 'distinct/inherent' methods as well as scientificity is still pending. In archaeology, an alternative way of establishment of digital methods may be visible nowadays—where digital tools are part of the

methodical repertoire of the entire discipline. Due to the conservative culture of other disciplines as art history we are in doubt if an adoption there will take place in a similar way. Against that background, our approach to subsume visually oriented branches of digital humanities may be fruitful since similar topics are addressed, the same technologies are used and discussed, as well as similar challenges—cross-disciplinarity and data—being faced. However, we cannot predict if future developments of digital cultures in these visual disciplines will progress in the same direction.

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## References

## Interviews

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- Postdoc Researcher in Digital Humanities.** 2016b. Interview #10.
- Interview #9.**
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- humanities applications – especially temporal overlaps with objects of archaeology. Methods for investigating genetic and morphologic connections are covered by analyzing style (Seippel, 1989; Suckale 2001). Another important range of methods is concerned with the meaning of the works of art (iconography) and systems of meaning (iconology) (Seippel, 1989). For more extended glance on methodology in art history, see Pächt (1986). *Methodisches zur kunsthistorischen Praxis / ausgewählte Schriften*, München, Prestel.
- Museology focuses on the presentation of research findings and reconstructions with the help of visualizations in museums in combination with didactically enhanced applications (Carrozzino and Bergamasco, 2010).
  - Archaeology investigates tangible remains and evidence of human culture (Renfrew and Bahn, 2005). *Archaeology. The Key Concepts*, New York, Routledge in order to generate a realistic representation of what exists now, and closely approximate what may have once been (Rua and Alvito, 2011). Often, the physical preservation of the objects is not intended. Therefore, a thorough documentation and data collection is even more crucial. Surveying techniques, especially laser scanning (Christofori and Bierwagen, 2013; Clini *et al.*, 2013; Lasaponara *et al.*, 2011) and image processing (Brutto and Meli, 2012; Martin-Beaumont *et al.*, 2013), as well as photos and plans, are used to document excavations in detail and provide sufficient data for a 3D reconstruction of objects.
  - The term Cultural Heritage refers, as a meta-science, to a wider scientific field which addresses multiple sciences and disciplines adopting their methods. Cultural Heritage, being tangible or intangible, provides the common subject to link the different approaches. On difficulties concerning the classification and transdisciplinary of Digital Heritage as an 'Agora', which may also be assigned to Cultural

## Notes

- 1 Art History investigates many of the objects that Cultural Heritage deals with, mainly works of art from the late antiquity to modern age, see Dilly (1979). While these objects themselves are tangible, Art History is also concerned with all tangible and intangible aspects connected with the work which provide insights about their origin and meaning (Locher, 2010). This provokes various interdisciplinary contacts and—in the context of digital visual

- humanities applications – especially temporal overlaps with objects of archaeology. Methods for investigating genetic and morphologic connections are covered by analyzing style (Seippel, 1989; Suckale 2001). Another important range of methods is concerned with the meaning of the works of art (iconography) and systems of meaning (iconology) (Seippel, 1989). For a more extended glance on methodology in art history, see Pächt (1986). *Methodisches zur kunsthistorischen Praxis / ausgewählte Schriften*, München, Prestel.
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- 4 The term Cultural Heritage refers, as a meta-science, to a wider scientific field which addresses multiple sciences and disciplines adopting their methods. Cultural Heritage, being tangible or intangible, provides the common subject to link the different approaches. On difficulties concerning the classification and transdisciplinary of Digital Heritage as an ‘Agora’, which may also be assigned to Cultural Heritage, see Ch’ng *et al.* (2013).
- 5 While the term ‘visual humanities’ is only rarely used in literature, there are currently only few other definitions available. According to Drucker, visual humanities deal with a ‘sophisticated information and interface design [that] treats the same people as subjects with advanced cognitive and interpretative abilities, where [they may respond quite differently, engaging much more deeply with the materials on offer [...].’ Citation according to Sattler (2014). The Association for Digital Humanities in Estonia defines a scope of visual digital humanities primarily against the background of ‘Representing and interpreting



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Moreover: In cooperation with commercial companies “[...] I have to give you something back. I’m not going to get it for the good of the country” (Phd Student in Geosciences, 2016; *Interview #5*).

- 24 ‘[Without funding] I couldn’t have the mapping  
[software] license’ (PhD student in geosciences 2016).  
25 The concept of mode 2 research was originally named  
by Gibbons *et al.* in 1994 (c.f. Nowotny *et al.*, 2003;  
Hessels and Lente, 2007). Some of the attributes

named here were initially reported by: De Solla Price (1963). *Little Science - Big Science*, New York, Columbia Univ. Press

- 26 One of the interviewees figured out that for PhD students in Humanities ‘in the end it’s their own personal journey’ (Professor in Computing, 2016; *Interview #2*). The ‘solo’ scholarship got reflected in several studies about humanities research (Given and Willson, 2018; Toms and O’Brien, 2008).